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PERFORMANCE EVALUATION OF QUEUING DISCIPLINE IN UMTS WCDMA NETWORKS

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ABSTRACT

Third generation of GSM technology (3GSM) has a Wideband-CDMA (W-CDMA) air interface. W-CDMA includes a shared high-speed channel for traffic from the base station to the mobile users. Queuing disciplines have now become the subject of intensive discussion in network field. There are several queuing disciplines that claim best performance. In this research paper, we implement five queuing disciplines (FIFO, PQ, WFQ, MWRR & DWRR) on UMTS WCDMA network for different multimedia traffic and analyze the performance of various queuing discipline on UMTS network. OPNET simulator is used to simulate the UMTS network. Intensive and close simulation perform on network over various queuing discipline and it shows that MWRR and DWRR show best and very close performance for all considered parameters except delay jitter and end to end delay where PQ seems better.

KEYWORDS: UMTS (Universal Mobile Telecommunication Architecture), Weighted-Fair Queuing, Deficit-Weighted Round Robin, Priority Queuing, Multi-Class Traffic, OPNET Simulator

I. INTRODUCTION

Universal Mobile Telecommunications System (UMTS) is a 3G wireless technology offering data rates up to 2Mbps. As the size of network and internetworking between networks is increase exponentially, various requirements are also evolving. A number of network parameters are there for measure their performances that are essential in different parts of network for different application. For example, real time applications are more delay sensitive than throughput whereas there is lot of applications where throughput is the most important parameter to be taken care of. To measure the performance of network a number of queuing disciplines have been proposed to ensure fairness between competing requests at a service point and achieve best performance. FCFS, Priority Queues, WFQ, MWRR, DWRR, ROUND ROBIN, FAIR Queuing etc. are some of the discipline. In this research paper, we measure the performance of Universal Mobile Telecommunication System under different queuing disciplines. UMTS network model is develop in OPNET with multimedia data i.e. FTP and voice. Simulation is performed for FIFO, WFQ, PQ, MWRR and DWRR queuing disciplines. Simulation is performed for MOS, Throughput, packet delay, end to end packet delay and delay jitter. By simulation results this research paper finally get the best queuing discipline with respect to different parameters. The rest of the of the paper is as follows. Section II covers related work to our experiment. In section III, we briefly describe UMTS network architecture. Section IV covers all five selected queuing disciplines with some comments on their performance. Section V states our simulation model. Section VI describes the simulation parameters Section VII discusses and analyzes simulation results to evaluate queuing disciplines performance in section VIII conclusion.

II. RELATED WORK

QoS, has checked the effect of various queuing disciplines when serving voice and FTP data traffic. A number of priority methods is adopted to configure the QoS in wireless networks. These priority methods are used to set the priority levels to different multimedia data. But our aim is enhance the wireless network performance [4]. Number of researches propose modified QoS mapping that differentiates the multimedia data according to the transmission of voice and video conferencing and other multimedia data. Weighted Fair Queuing scheduler is used to schedule the transmissions according to different priority weights assigned for multimedia services. By using a detailed simulation experiments and results, the results show the effect of queuing delays on multimedia traffic types. A little work found on DWRR in literature. For real-time traffic Dynamic Weighted Round Robin (DWRR) scheduling strategy is most suitable. Real time variable bit rate (rtVBR) service and other services such as constant bit rate (CBR), available bit rate (ABR), non real-time VBR (nrtVBR) services used in UMTS network to transmit multimedia data.

III. UMTS ARCHITECTURE

The most important 3G cellular system is Universal Mobile Telecommunications Systems (UMTS) which uses WCDMA for the air interface. UMTS keeps the concepts and solutions of the GSM network but a new infrastructure is required. The UMTS architecture is illustrated in Figure 1 and is composed of three main domains [5]: User Equipment (UE), UMTS Terrestrial Radio Access Network (UTRAN), and the Core Network (CN). The UE is the equivalent of the MS in GSM, with added support for UMTS. The Core Network is based on the GSM/GPRS network upgraded in order to support UMTS operation and services. The UTRAN provides the air interface for the UE, and is the equivalent of BSS in GSM, consisting of two main entities: Node B and Radio Network Controller (RNC). Node B is the equivalent of BTS whereas RNC is the equivalent of BSC. A RNC can control one or more Node Bs.

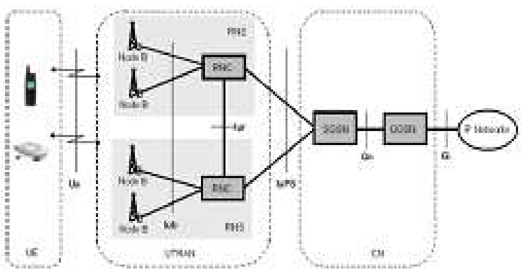

Figure 1: UMTS Architecture

Figure 1 Shows the UTRAN Architecture. the CN Includes the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN)

IV. QUEUING DISCIPLINES DESCRIPTION

We have preferred five different queuing disciplines for our Simulations: FIFO, PQ, WFQ, MWRR and DWRR. The queuing disciplines are as follows;

A. First In First Out (FIFO)

In FIFO queuing, packets arriving from different flows are treated accordingly to their arriving order. This means that the first packet that got in the queue will be the first that will go out. FIFO queuing is the basic queue scheduling discipline among others. In FIFO queuing, all packets are equally treated. All packets are placed in a single queue, and then serviced in the same order they arrived in to the queue. FIFO queuing is stands for First come, First served (FCFS) queuing. There is no multitasking and no preemption. The advantages of FIFO are its predictable behavior; extremely low computational load on the system, simple contention resolution, guaranteed fairness etc. but the downside of FIFO is in capability to provide priority to real time traffic, delay insensitivity due to which mean queuing delay increases rapidly.

B. Priority Queuing (PQ)

PQ is same as FIFO. In PQ, more than one queues are assigned at output links based on their priorities, packets that reaches at the output link are differentiated into more than one queues that is based on their priorities. A series of filters based on packet characteristics. Traffic is placed into different queues. The queue having the highest priority will be the first to be serviced, while lower priority queues will be serviced in a priority sequence. If the queue with the highest priority is always full, then this queue is constantly serviced and all the packets from other queues are dropped. When using the Priority Queuing algorithm the highest priority traffic will dominate all others kinds of traffic. Priority queuing assigns all the traffic to one of the following four queues: high, medium, normal, and low. The packets which have highest priority are then served first, further second higher priority packet will served and so on. For assign priority to various packets packet header is used, a priority bit is set to its source or destination IP address, its destination port number, or any other criteria. Each priority class should maintain its individual queue. Whenever a packet is to be transmitted, the priority queuing mechanism will transmit a packet of highest priority class to a highest priority queue that has a nonempty queue. If the transmitted packets are of the same priority level then selection among packets for same priority class is typically perform in a FIFO manner. The problem with PQ is that lower-priority packets always ignored and could be wait for a long time for execution.

C. Weighted Fair Queuing

WFQ (Weighted Fair Queuing) is a good queuing technique. The main goal behind WFQ [39] was to ensure equality among all types of traffic and prevent bursty data to consume more bandwidth than its allocation [39].To reduce the response time WFQ schedules interactive traffic to the front of the queue.WFQ fairly shares the remaining bandwidth between high bandwidth flows. It is not possible to have one queue for each conversation, WFQ uses a hashing algorithm. This hashing algorithm divides the traffic over a limited number of queues that is selected by the user or it is fixed by default. This takes care of fairness of the algorithm.

D. Modified deficit Round Robin Queuing Discipline(MDRR)

MDRR configured as a number of queues that contain data are served one after another in round robin strategy. In first pass each time whenever a queue is executed or processed, a fixed amount of data is dequeued. After the processing of one queue the algorithm then process the next queue. When a queue is processed, MDRR maintain record of the number of bytes of data that was dequeued in excess of the configured value. In the next pass, when the queue is processed again, a lesser amount of data will be dequeued to recompense for the excess data that was processed formerly. As a result, the average amount of data dequeued per queue will be close to the configured value. MDRR also maintains a priority queue

that gets processed on a privileged basis. Each queue within MDRR is defined by two variables:

- **Quantum Value** – This variable contain average number of bytes served in each round.
- **Deficit Counter -** This counter is used to track how many bytes a queue has transmitted in each round. It is initialized to the quantum value.

D. Deficit weighted Round Robin (DWRR)

DWRR is a modification of the WRR algorithm. In WRR queuing, packets are first differentiated into various service classes and then assigned to a queue that is exclusively dedicated to that service class. Each of the queues is serviced in a round-robin order. Similar to strict PQ and FQ, empty queues are skipped that enables to save the service quantum of the flow served. They do not receive packets in around robin fashion because of variable size in order to maintain timeliness performance [9]. That is, if a packet from a flow being currently served is so long that its transmission would exceed the service quantum this round-robin, the resulting amount of service undelivered to the flow is saved until the next round-robin and is added to the service quantum. It also addresses the limitations of the WFQ model by defining a scheduling discipline that has lower computational complexity and that can be implemented in hardware. This allows DWRR to support the arbitration of output port bandwidth on high-speed interfaces in both the core and at the edges of the network. However DWRR does not provide end-to-end delay guarantees and delay jitter as precisely as other queue scheduling disciplines do because while maintain fairness, the overall end-to-delay may get disturbed.

V. SIMULATION MODEL

OPNET (14.5) simulator is used for deploying UMTS network architecture by using different nodes (mobile & fixed) from object palette. OPNET MODELER [8] is used for design and study communication networks, devices, protocols and applications. It provides a graphical user interface to build simulation models for various network parts from physical layer modulator to application processes [6] [7].

Simulation Scenario

For implementation of various queuing disciplines on UMTS network five scenarios have been created, i.e. FIFO, PQ, WFQ, DWRR and MWRR. We apply all the five queue disciplines on links between various components of UMTS networks one after the other which directly implies that we have five different scenarios, one scenario for each queue scheme is used. There are two types of traffic: FTP and Voice. For each traffic type a different server is used. We use Constant traffic for FTP, voice over IP call (PCM quality) speech for voice (ToS is interactive voice (6)) and Encoder scheme is GSM FR with voice frames per packet is 2. For the application of queuing disciplines, we use QoS attribute of OPNET. All the links other than the one between two routers are 10BaseT.A single scenario completed in all aspects, duplicated and then attributes are set for all the scenarios. Each scenario is employed for file transfer by using Background class and voice conferencing by using conversational class. Each scenario is designed for five users i.e. FTP user and voice user with their movement across Node-B. Along with users, simulation model consists of following entities: three Node-B access points, two RNC, two SGSN, GGSN and one FTP server and one voice server for different traffic class. For connectivity between nodes various links were used form object palette. After the architecture is completed, the required attributes are set for each node.

Applications are defined in the application configuration node and QOS parameter configuration is used to set parameters for various queues. For each queuing mechanism different

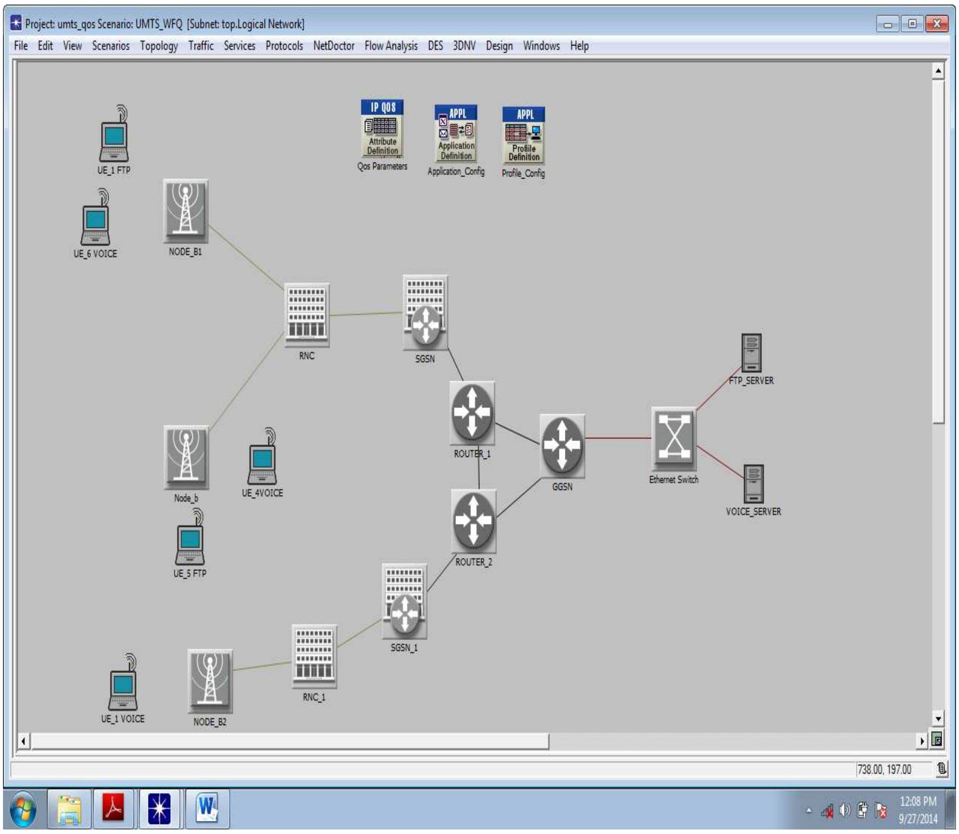

Figure 2: UMTS Simulation Model for Different Queuing Policy

scenarios are designed for measuring the different global and object statistics. Figure 2 shows the simulation scenario for WFQ. Here we show only one scenario.

VI. SIMULATION PARAMETERS

Various simulation parameters are to be considered for performing simulation on OPNET simulator.

E. Scenario Parameters

- For each scenario certain parameters are considered and need to be set as shown in table 1

Table 1:Simulation Parameter

Simulation Parameter	Value
Simulation Time	300 Sec
Number of Nodes	05
Environment Size	Logical Environment
Traffic Type	Constant Bit Rate
Seed	300
Value per Statistics	300
Update Interval	500000
Simulation	Based on Kernel type Preferences
Number of runs	One for each scenario

VII. SIMULATION RESULTS

After analysis of results various parameters needs to be considered are Scenario parameters, profile configuration parameters, QOS parameter Configured application configuration parameters. Analyzing various queuing discipline results by implementing various queuing configuration on UMTS network. Number of simulations was executed and results recorded saved and compared. As shown from results graph below we can see that DWRR compared to other queuing schemes behaves well in terms of jitter and packet delay variations.

F. Global Stastics

These static is collected for Voice conferencing i.e. Jitter, MOS, Packet Delay Variation, and Packet End to End Delay, Voice Traffic Sent and Received. Figure 4 shows the jitter for all five queuing disciplines in UMTS networks. This graph shows that DWRR have smooth curve for jitter.

For analyzing queuing disciplines voice users are added to check the performance of on UMTS network. Simulation results are analyze by a number of performance parameters like jitter, MOS, Packet delay variation and Packet end to End Delay. By all these performance metric results are checked for all queuing disciplines and for Non QoS scenario also.

- **Jitter**

Jitter represents if two consecutive packets leave the source node with time stamps t1 & t2 and are played back at the destination node at time t3 & t4, then:

Jitter = (t4 - t3) - (t2 - t1)

Negative jitter indicates that the time difference between the packets at the destination node was less than that at the source node .Figure 3 shows the jitter in all queuing disciplines.

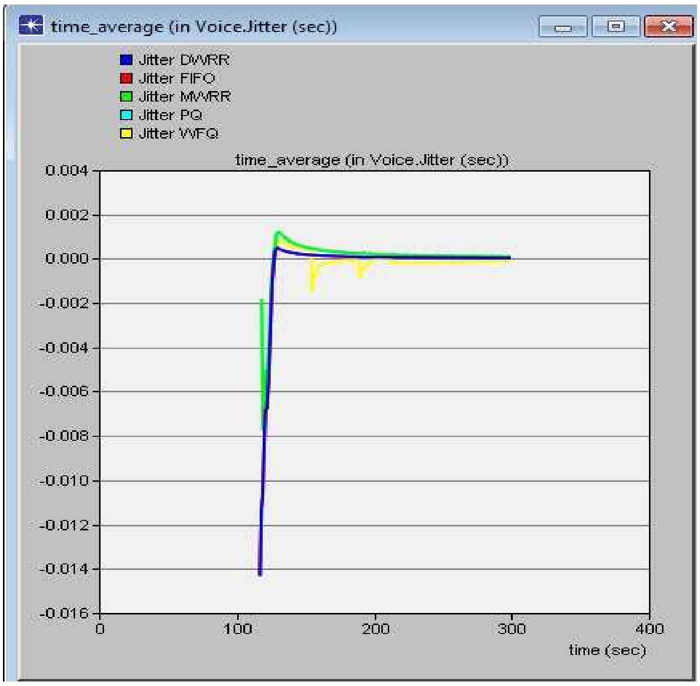

Figure 3: Comparative Analysis of all Queuing Discipline for Jitter

- **MOS**

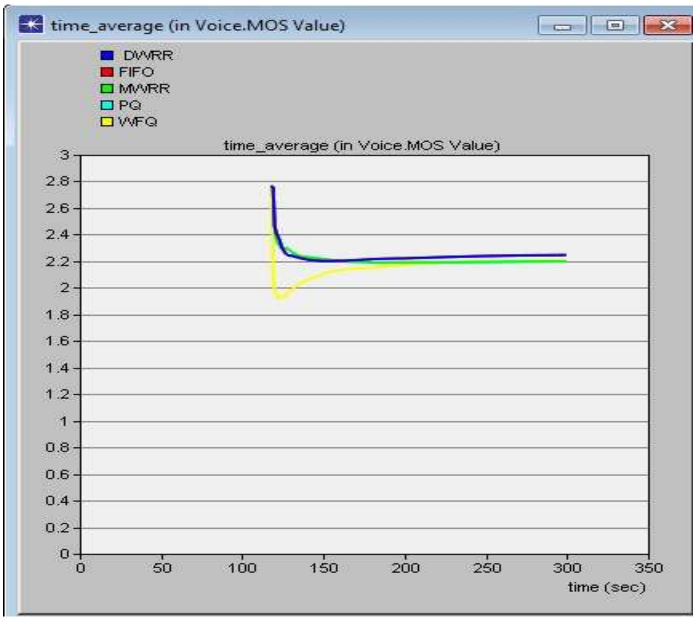

Figure 4: Comparative Analysis of al Queuing Discipline for MOS

Figure 4 shows the results obtained of MOS for all queuing disciplines and it shows that at the starting time the value of MOS is approx 2.8 but as the time expand the quality of voice is degraded and comes to approx 2.2 which is same for all queuing disciplines. Graph shows that the MOS for WFQ is not good and it comes to approx 1.9 which is not good for quality of voice. Whether the MOS value of DWRR is approx 2.8 to 2.1 which shows a good quality of voice.

- **Packet End to end Delay**

The total voice packet delay, called "analog-to-analog" or "mouth-to-ear" delay = network delay + encoding delay + decoding delay + compression delay + decompression delay

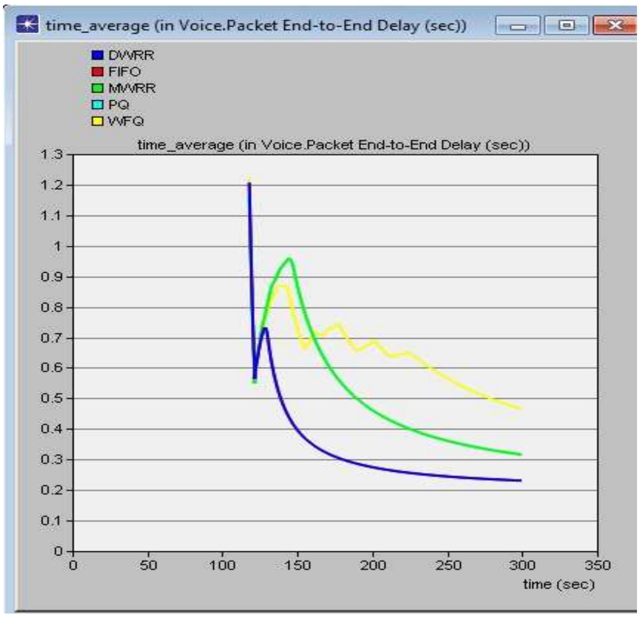

Figure 5: Comparative Analysis of al Queuing Discipline for Packet End to End Delay

Network delay is the time at which the sender node gave the packet to RTP to the time the receiver got it from RTP. Encoding delay (on the sender node) is computed from the encoder scheme. Decoding delay (on the receiver node) is assumed to be equal to the encoding delay.

Compression and Decompression delays come from the corresponding attributes in the Voice application configuration..This statistic records data from all the nodes in the network.

Figure 5 shows comparative analysis of packet end to end delay for all queuing discipline and it shows that packet end to end delay is minimum for DWRR queuing, whether it is maximum for WFQ.

- **Packet Delay variation**

Packet delay variation among end to end delays for voice packets. End to end delay for a voice packet is measured from the time it is created to the time it is received.

Figure 6 shows the packet delay variation for all queuing disciplines. The results show that DWRR shows less packet delay variation rather than other queuing disciplines. Initially at the time of approx 100 seconds the packet delay variation of all queuing disciplines are same but gradually it increases and finally after approx 150 seconds t gradually decreases.

The result shows that, packet delay variation for DWRR is less in compare to other queuing disciplines. Packet delay variation for MWRR and WFQ is quite same but WFQ shows more packet delay variations.

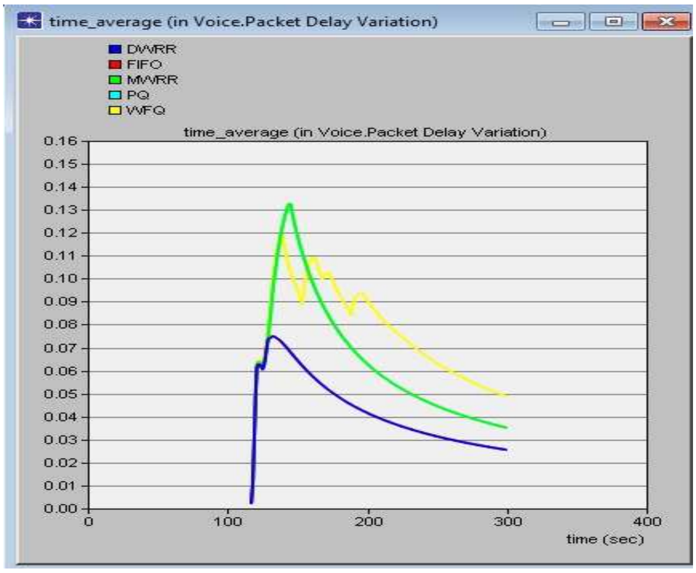

Figure 6: Comparative Analysis of all Queuing Discipline for Packet Delay Variation

Graph shows that DWRR shows less packet delay variation. While MWRR shows the high packet delay variation.

CONCLUSIONS

In this research paper a comparison is perform for different queuing discipline over UMTS network. The results show that DWRR gives the minimum queuing delay for multi-class traffic. Moreover, the packet drop rate is also minimal incase DWRR. Although MWRR, PQ and WFQ shows very close result to DWRR but DWRR and WFQ queuing schemes maintain fairness well. In future we explore the all the advantages of DWRR over other queuing disciplines. OPNET

provides a very intensive and real environment that clearly shows UMTS network performance when we implement different queuing discipline.

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